CHAPTER 1

s = distance (m)
u = initial velocity (m/s)
v = final velocity (m/s)
a = acceleration (m/s^2)
t = time (s)
F = force / weight (N)

$$v^2 = u^2 + 2as$$

$$s = ut + \frac{1}{2}at^2$$

$$v = u + at$$

$$s = \frac{v+u}{2} \times t$$

$$s = vt - \frac{1}{2}at^2$$

$g = 9.8\ m/s^2$

Taut: Pulled tight, not slacked

Types of forces:

(i) Weight
(ii) Normal Reaction
(iii) Friction
(iv) Tension
(v) Thrust / Compression
(vi) Buoyancy
(vii) Air resistance / Drag
(viii) Upthrust / Lift

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Model	Description	Modelling assumption
Particle	Dimensions of the object are negligible	• mass acts from a single point • air resistance & rotational forces can be ignored.
Rod	All dimensions except one is negligible. Like a pole or beam	• mass concentrated along a line • no thickness • rigid (does not bend)
Lamina	Object with area but negligible thickness	• mass is distributed along a flat surface
Uniform body	Mass is distributed evenly.	• mass acts from centre at a single point
Light object	negligible mass, like string, pulley	• treat object has zero mass. • tension same at both ends
Inextensible string	Does not stretch under load	• acceleration is same in objects connected by a taut inextensible string
Smooth surface	No friction	• no friction between object and surface
Wire	Rigid thin length of metal	• treated as one-dimensional
Smooth and light pulley	Same for all pulleys	• pulley has no mass • tension is same on either side of the pulley
Bead	Particle with a hole through	• moves freely along a string • tension same on either sides
Peg	support from which a body can be suspended or rested	• dimensionless and fixed • can be rough or smooth
Air resistance	Resistance experienced while moving through air	• usually modelled negligible
Gravity	Force of attraction between all objects	• acts downward & constant • $g = 9.8\ m/s^2$

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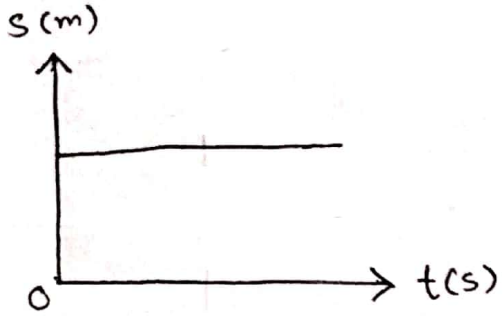
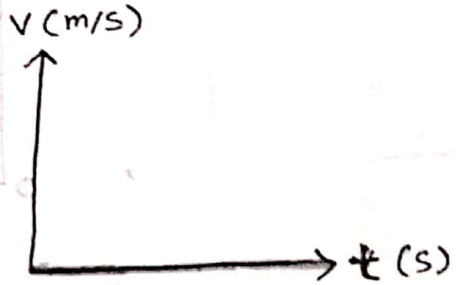
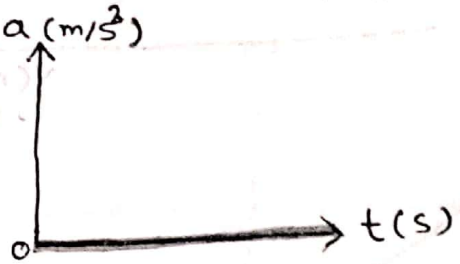
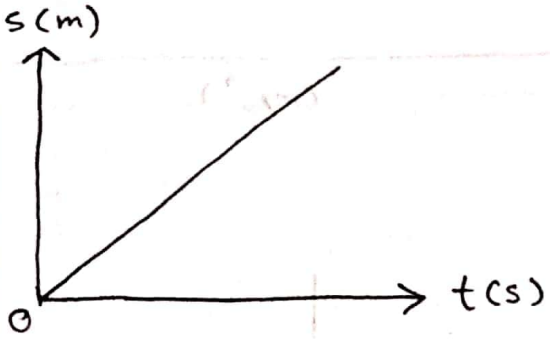
CHAPTER 2



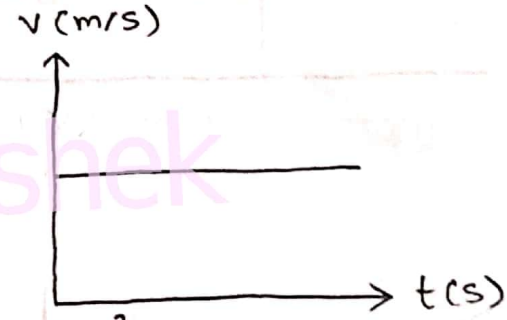
- displacement unchanged
- object stationary (v = 0)
- acceleration zero

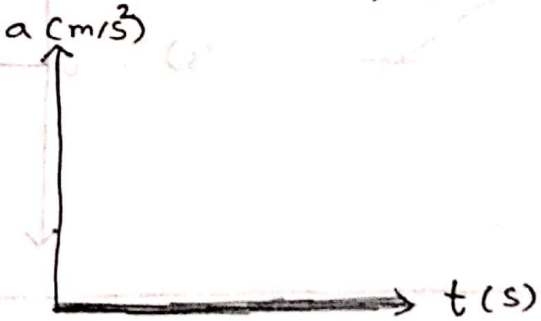


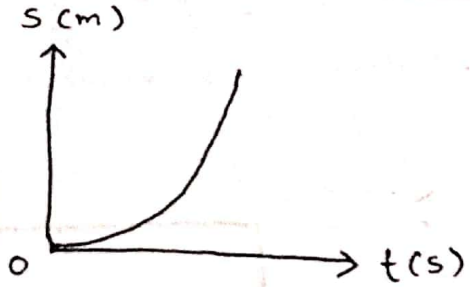




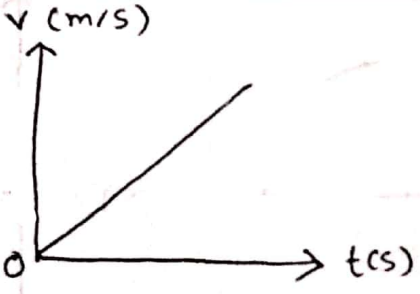
- displacement increases at a constant rate
- velocity is constant
- acceleration zero

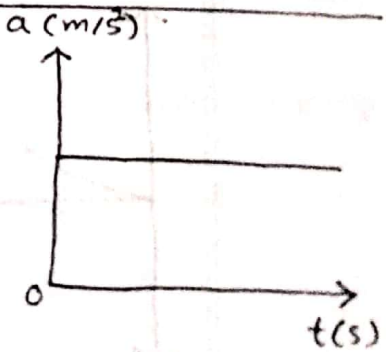






- displacement increases at an increasing rate
- velocity increases
- constant velocity





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Type of graph	Area under graph	Gradient
displacement - time	X	velocity
velocity - time	displacement	acceleration
acceleration - time	velocity	X

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- Negative acceleration = Deceleration = Retardation
- At turning point, object must come to instanteneous rest for a moment.
- Initial speed = Speed of projection
- Time of flight = Total time it is in air
- At maximum height, velocity is zero
- The speed at which a balls hits the ground is the initial speed that it was thrown with upwards.

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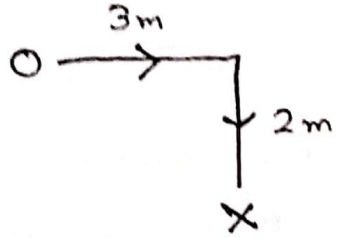
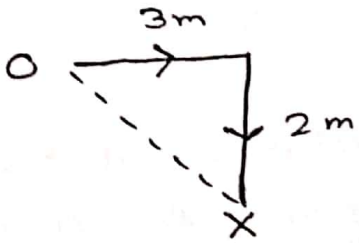
CHAPTER 3 | VECTOR

- Unit vector is a vector of length 1.
- Displacement, is the shortest length between 2 points

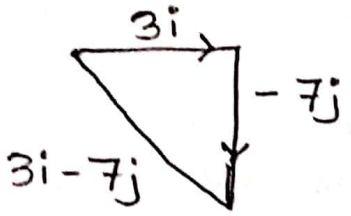


distance = 5 m



displacement = $\sqrt{13}$ m

- When a vector is in written in i-j vectors, magnitude can be found using the Pythagorus Theorem.



$$|v| = \sqrt{3^2 + (-7)^2}$$
$$= \sqrt{58}$$

- If two vectors are parallel to each other, their gradients are same, so ratio of their i-j components in also equal.

- If particle is resting in equilibrium then the resultant of all forces acting on it is zero. Sum of vectors of forces is zero vector.

- $r = r_0 + vt$

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CHAPTER 4 | Dynamics of Particle

- A resultant force causes an object to accelerate.
- $\begin{pmatrix} 5 \\ 3 \end{pmatrix}$ N is the same as $(5i + 3j)$ N
- $W = mg$
- If connected particles move in a straight line, then we can assume them as a single particle. (They must be connected, with a rod or taut string to be considered as a single particle)
- Newton's 3rd Law of Motion: Every action has an equal and opposite reaction.
- The tension in a string in a smooth pulley will be same on both sides.

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CHAPTER 5 | FRICTION

$\cos 0^\circ = 1$

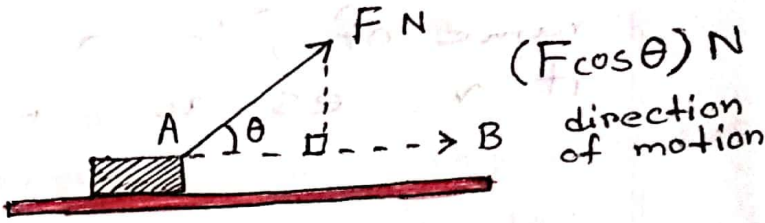
$\cos 45^\circ = \frac{\sqrt{2}}{2}$

$\cos 90^\circ = 0$

$\sin 0^\circ = 0$

$\sin 45^\circ = \frac{\sqrt{2}}{2}$

$\sin 90^\circ = 1$

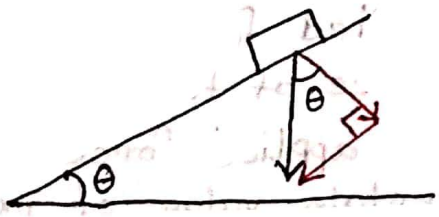


If force is applied at an angle to the direction of **motion**, we resolve it to find the component of the force that acts in the direction of motion.

Hint: line near the angle = $F \cos\theta$

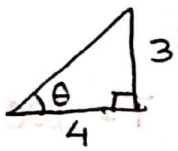
line opposite to angle = $F \sin\theta$

Inclined plane:



$\tan\theta = \frac{3}{4}$

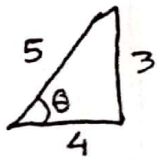
$\therefore$



$\text{hypo} = \sqrt{3^2+4^2}$

$= 5$

$\therefore$



$\sin\theta = \frac{3}{5}$

$\cos\theta = \frac{4}{5}$

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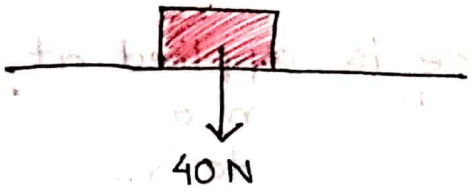
FRICTION

Value of friction is not constant all the times; it varies according to the force applied.



No horizontal forces, so friction is zero.

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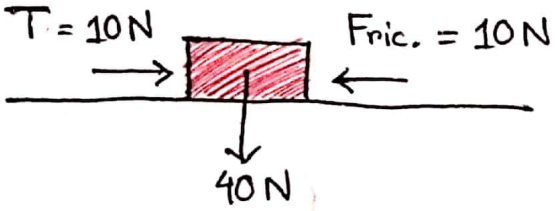
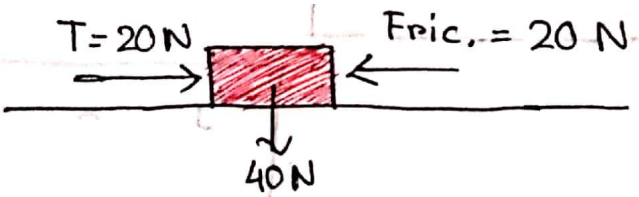
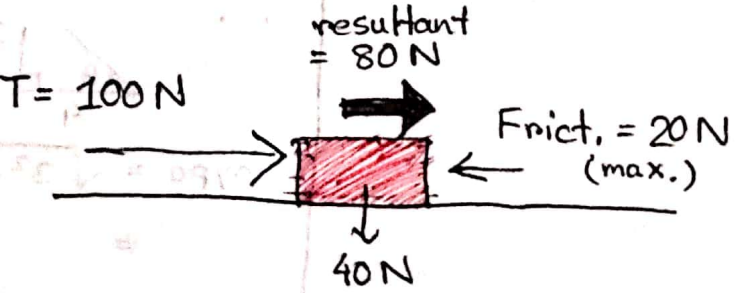


Horizontal force is 10 N, so friction also 10 N, no resultant forces, so box at rest.



Same as above



If applied force increases, the force of friction increases, If the applied force exceeds a certain value or maximum or limiting value, block will move. Force of friction will be constant and at its maximum.

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- When a particle is on the point of moving it is said to be in limited equilibrium. (Object can be at rest/constant velocity)

- Limiting value of Friction depends on:

  (i) normal reaction **R** between two surfaces in contact

  (ii) roughness of two surfaces in contact, μ

- $\boxed{F_{max} = \mu R}$

μ ↑ coeffient of friction

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CH-6 | MOMENTUM, IMPULSE

- Momentum of a body of mass **m** which is moving with velocity **v** is mv $(kg \cdot m/s)$
- **I**mpulse of force is defined as a constant force **F** acting for time **t**, **Ft** (Ns)

$$F = ma$$

$$\Rightarrow F = m \times \frac{v-u}{t}$$

$$\Rightarrow Ft = m(v-u)$$

$$\Rightarrow I = mv - mu$$

Impulse-momentum principle

Impulse = change in momentum

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Force = rate of change of momentum

CONSERVATION of MOMENTUM:

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

Total momentum before = Total momentum after

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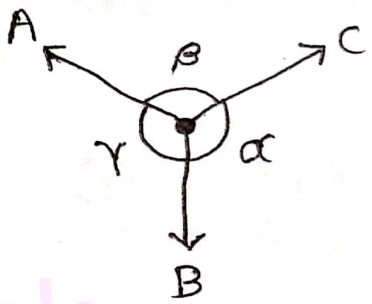
CH-7 | STATICS OF A PARTICLE

- A particle is in static equilibrium if it's at rest.

- Lami's Theorem :

$$\frac{A}{\sin\alpha} = \frac{B}{\sin\beta} = \frac{C}{\sin\gamma}$$



- $F \leq \mu R$

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CH-8 | MOMENTS

- Moment of a force measures the turning effect of the force on a rigid body.
- Moment = Force × distance (perpendicular to the line of action of force)
  (Nm) (N) (m)
- Lamina – 2D object with zero thickness
- Sum of moments acting on a body is called the resultant moment.
- Coplanar forces are that act in the same plane.
- At equilibrium, sum of clockwise moments and sum of anticlockwise moments is equal.
- If a rod is non-uniform, the centre of mass is not at the mid-point of the rod.

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